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THE LIFE HABITS OF POLYPTERUS.

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a. *Living* (*Resting*), b. *Feeding;* c. *Swimming;* d. *Breathing;* e. *Reproduction.*

REFERENCE has already been made to the occurrence of Polypterus in the Lower Nile (*Science*, Vol. V, 1898, Oct. 23, p. 54, and 1899, March 3, p. 315). The purpose of the present paper is to give a number of additional notes as to the occurrence and habits of this interesting and little-known fish. These details are treated in the following order:

Polypterus bichir differs but little in its habits from the other fresh-water fishes of the Nile. It lives in the deeper depressions of the muddy river bed, but it is an active swimmer and not essentially a bottom-liver or a mudfish. It is most active at night time when it is in search of its food.

Feeding. — Trawl lines were largely used as a means of collecting. They were laid late in the afternoon and left set all night. In the early morning, by three or four o'clock, besides many other large fish, a few Polypteri would usually be taken. Sometimes, however, specimens would be taken during the early morning in the second going-over of the trawls. Aside from small siluroids, Armoot, Bayad, Schilbe, Schal, which were commonly used as bait, Polypterus eats a great many other teleosts, as is evidenced by the more or less undigested remains in the stomachal pouch of such forms as Cyprinodon, Anguilla, and Chromis. It apparently catches them alive, for it prefers live bait and always swallows its food whole. Although catfish are usually taken head first, some fish were found in the stomachal pouch in a reverse position; their undigested remains are probably ejected through the mouth. The pouch is admirably adapted for resisting the very dangerous and strong spines possessed by all the catfishes.

On account of the great vitality of the siluroids they probably remain alive for some time after they are taken into the digestive tracts ; but their strong pectoral and dorsal spines, which close backward against the body, are kept from doing any harm by the strong muscles of this gastric pouch, which compress the enclosed fish and prevent the erection of its spines.

Swimming. — Peculiar in the swimming movements of Polypterus is the manner in which the head moves freely from side. This produces the appearance of a progression more or less snake or eel-like, although in general the powerful sweeps of the strong tail characterize the progression as fish-like.

The pectoral fins were never observed to be used otherwise than are the pectoral fins of most other fishes, *i.e.*, primarily as balancing organs, but partly as organs of progression. There is no evidence that Polypterus uses its fins in the manner figured by Klaatsch in Gegenbaur's *Festschrift* (Vol. III) as organs for walking or crawling. The spreading cartilaginous pectoral fin rays give a mobility to the pectorals which is strikingly and beautifully displayed in a high development of the "trembling movement," so often seen in the balancing fins of teleosts.

The long dorsal fin is not always erect when the animal is swimming. It can be raised or lowered at will.

Breathing. — In spite of repeated observations, there is little positive evidence that Polypterus comes often to the surface to breathe. The evidence which can be presented concerns a number of fish, which were confined in a large wicker basket partially immersed in the river. In swimming around the narrow limits of this cage the Polypterus would stick its head out of water, but no more than would any fish similarly confined. On one occasion, while fishing a few miles above Damietta, we saw a Polypterus, about forty feet from us, thrust the anterior end of its body six inches out of the water, make two or three gasps, and then swim slowly away. But this fish, like many others found in the locality, was dying from the increased salinity of the water at this point, caused by the unusually low Nile and the backing up of the Mediterranean at high tide.

Although the fish was not often seen taking in air, the following fact goes to show that a respiratory function is possessed by the swimming bladders or lungs. When the fish is opened alive, a marked peristalsis may be observed making its way along the right (larger) lobe of the so-called lungs. These structures open by the common large (about 2 cm. long) glottis into the pharynx, and they contain normally about four or five hundred cubic centimeters of air. A further discussion of the respiratory function of these bladders will be given later, when their histology can be discussed ; but their principal resemblance to amphibian or reptilian lungs is shown in the relations of the capillaries and the arrangement of the blood vessels running to and draining them.

REPRODUCTION.

1. Migration. 2. Time and place of breeding. Manner of fertilization — size and character of eggs. 3. List of fish as to ovaries.

1. *Migration.*—Several of the fresh-water fishes found in the Nile migrate each season to the Mediterranean to spawn. This is the case with the eel (Hanash) and the several species of mullets. It has never been supposed that Polypterus could be found in any considerable numbers north of the second cataract, so that there seemed to be little likelihood that this fish migrated. When, however, fish were found in this lower part of the river more abundantly than in any other part known, except the head waters, it became a possibility that Polypterus had migratory habits. Investigation of the distribution of Polypterus at points intermediate to the second cataract and the mouth showed that in the large brackish Lake Menzaleh, an enlargement of the Delta, no adult fish could be got, although it was reported that two young Polypteri were obtained here the year before. The single specimen in the Natural History Museum at Cairo was the only one which had been seen in the local markets there for a number of years. At Assiout, 325 miles from the sea, the fishermen did not recognize the stuffed specimen shown them, but when the name, "aboubichir," was mentioned they said that such a fish was occasionally found there ; that it came from bad crocodiles' eggs and went down the river, while the good eggs brought forth young crocodiles that went up river!

The preceding facts as to distribution indicate that the fish does not pass by these several stations below the second cataract. It is, therefore, probable that the very considerable number of fish, which were taken over a limited territory, only a few miles in extent, were not individuals who were migrating, but fish that were living the year round in this locality. They were, in the full sense of the terms, healthy normal fish, and seemed to frequent certain holes, where they could repeatedly be taken with a circular throw-net. The males are smaller than the females, and although they are much less numerous, are generally taken in company with one or more females.

Aside from the lack of evidence as to Polypterus being a migratory fish that can be deduced from the facts of distribution, the continuance of mature individuals at Mansourah for a period of three months cannot be explained on the migration hypothesis. But the principal fact bearing against the latter view is that the adult fish is so affected by salt water that a slight increase in salinity kills it. On June 10, at Inanieh, a point four miles from Damietta, we came upon a number of dead Polypteri thrown up on the bank. The water was slightly brackish, and the fish evidently had been killed by some such particular cause. No other kinds of fish were found dead. The salt water, which had reached this point owing to the low Nile, continued to back up the river, until seven weeks later, August 2, it had reached Toela, some thirty miles from the sea. Being then stationed at Mansourah, a number of fish were brought in to us, which for the first time during our stay here were not fresh. Rigorous cross-questioning brought out the fact that they had been picked up dead upon the river bank at this town, Toela, which was now dependent on the canals for drinking water and irrigation, the Nile there being brackish. Several of the fish which had been killed by the salt water were heavily laden with eggs.

The chief reasons, therefore, for believing that Polypterus is not a migratory fish are: (1) It is unrecorded, in any numbers, at points intermediate between Mansourah and the second cataract; (2) females remain at Mansourah for several months longer than the actual time required for spawning; (3) the mature fish do not survive salt water long enough even to shed their ova.

2. *Place and Time of Breeding.* — If the specimens taken at Mansourah are not migrating, where and when does Polypterus breed? Probably at any point on the river where the adult fish may be found in numbers. Such regions are presumably to be found about the head waters of the Nile, and it is possible, further, that, like some other river fishes, they prefer the small brooks or springs for spawning. There seems to be no reason, however, why the few fish, which are found heavily laden with eggs at Mansourah, should not spawn in this vicinity, *i.e.*, below the first cataract; for it is practically impossible for them to pass the barrage. Besides the individuals taken with eggs, others were observed, the ovaries of which retained only here and there a few large ova still attached, the remainder having evidently been cast out.

The time of the breeding of Polypterus can be approximately determined not only by the gradual ripening of the eggs from June to September, but since the spawning seasons of nearly all Nile fishes correspond in a rough way, there is evidence that Polypterus probably breeds during or just after the inundation of the Nile. Cyprinodon, which brings forth its young alive, was one of the earliest fish to spawn, and its eggs had all disappeared before the middle of July. Between this time and the first of September, Schal, Schilbe, Bayard, and Armoot, in the order named, laid their eggs. The latter spawned latest, and its eggs during the summer seemed to keep pace in ripening with those of Polypterus.

Copulatory Organ. — The anal fin of the male Polypterus, which has already been described as being somewhat larger than that of the female, is undoubtedly a copulatory organ. When the fish is alive, this fin, if blown upon or irritated, assumes a hollow and pointed spoon-shaped appearance.

List of Fish Taken. — There follows a partial list of the fish taken during the summer, with occasional reference to the condition of the reproductive organs.

June 10. 7–8 bichir, principally dead females which carried large numbers of ova.

June 14. Two living bichir from Ras-el-Ghelig. Females with eggs.

June 15–20. Several dead brought in from banks of Nile

June 22. Two from market at Mansourah.

June 25. Two.

June 27. One.

July 2. Two males and two females. A promising but unsuccessful trial to rear larvæ was obtained from this material by means of artificial fertilization, the females bearing well-advanced eggs (which could not, however, be readily shaken from the ovarian stalk), and the sperm being fairly active.

July 3. One male with immature sperm.

July 4. Two females, both with eggs.

July 5. One male, two females.

July 6. Three females, one of whom had shot eggs.

July 7. Three females, all with eggs.

July 8. One female.

July 9. One female with eggs.

July 10. Three females, two large specimens with eggs, one small without.

July 11. Three females, two large with eggs, one small without.

July 13. One large female with eggs.

July 14. One large female with eggs, one small without.

July 15. Two large females with eggs.

July 16. One large and one small female, both with eggs.

July 17. One large female with eggs.

July 18. Two large females with eggs.

July 20. One female.

July 21. One small male, one large female with eggs.

July 22. Two females.

July 25. One small male, one female with eggs.

July 26. One small male and two large females, both with eggs.

July 27. Five females, all with eggs ; one small male.

Aug. 1. One very large male (rather smaller than average large female).

Aug. 2. Two large females, one had shot eggs.

Aug. 3. Three fish from Toela (salt water), one male, two females.

Aug. 4. One small male, one large male, one female which had shot her eggs.

Aug. 5. Five females, three with eggs, two had shot eggs ; all below average size.

Aug. 8. A pretty pair, male and female, apparently caught in same net. Female without eggs, male with striking copulatory anal fin.

Aug. 9. Three not designated.

Aug. 10. Two not designated.

Aug. 15. One not designated.

Aug. 21. Two, both females full of eggs.

Aug. 24. One large female with eggs.

Aug. 25. One.

Sept. 1. Female at Damietta with eggs.

A review of the above list shows plainly that the greatest difficulty we found in getting the developmental stages at Mansourah by artificial fertilization was the scarcity of mature males. There were only twelve males to fifty-eight females. Although sexually mature individuals of both sexes will be seen to have been brought in the same day, it was found exceedingly difficult to keep one promising specimen alive and healthy until an equally promising mate could be secured. As many as fifteen fruitless attempts were made to raise larvæ, by mixing sperm that moved actively with eggs which appeared ripe (although these could never be shaken from the ovarian stalks in large numbers).

This practical difficulty in keeping Polypterus in confinement is due to the fact that it is not an especially hardy fish. It will not survive more than three or four hours out of water, and only then under the most favorable conditions ; that is, covered with damp grass and weeds. The Nile catfishes Clarias and Bagrus, on the other hand, retain an unimpaired vitality after twice as long an exposure to similar conditions. It is well known that these catfishes have accessory branchial organs, and some species make considerable journeys overland. Physiologically at least, therefore, Polypterus has not evolved very far toward a land-living or even an air-breathing type, although morphologically, *i.e.*, especially in its organs of respiration and circulation, it certainly presents the essential characters of the lower amphibia. They are feebly developed in some respects, but nevertheless include all the morphological and physiological potentialities of a higher vertebrate. On the other hand, in the possession of spiracles and in primitive skeletal characters, it strongly resembles the oldest fishes (Elasmobranchii). Several writers have recently contributed very convincing evidence that crossopterygians were lineal ancestors of the higher vertebrates, but judging from the conditions in Polypterus they were also sufficiently remote in the phylum of vertebrates to have given rise to both dipnoans and amphibians.

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